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DETERMINATION OF YIELD AND SOME QUALITY TRAITS IN HULLED (*Hordeum vulgare* L.) AND HULL-LESS TWO-ROW BARLEY *(Hordeum vulgare* L. var. *nudum* Hook f.) GENOTYPES

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ABSTRACT

In this study; hulled barley (Aydan Hanim and Tosun Pasa), hull-less barley cultivar (Yalin) and lines (INBYT6, INBYT16, INBYT18, ABA7, ABA8) were compared for grain yield and some quality characteristics, and the adaptability of hulled and hull-less barley lines to Isparta ecological conditions was determined during 2019-2021 years. The differences between genotypes and years in the examined characteristics were found to be statistically significant. According to the two-year average results, the plant height of the hull-less barley lines was shorter than the cultivars, the number of spikelets and grains and the thousand-seed weight were lower, the grain and biomass yields were lower except for the ABA8 and INBYT18 lines, and the test weight was higher in the others except the ABA7 line. As a result, it has been determined that hull-less barley can be grown in Isparta ecological conditions and INBYT18 (3702.7 kg ha^{-1}) and ABA8 (3881.3 kg ha^{-1}) lines are more suitable for these ecological conditions in terms of grain yield. In addition, it was determined that the crude protein rate was higher in hull-less genotypes.

Keywords: Biomass yield, grain yield, hulled and hull-less barley, quality.

INTRODUCTION

Barley is an important cool climate cereal cultivated worldwide. The cultivation area of barley in the world is approximately 51.15 million ha, production is 159 million tons and average yield is 3108 kg ha^{-1} (Anonymous, 2020). In Turkey, the cultivation area of barley is approximately 3.1 million ha and the production is 5.7 million tons. The average yield is 1810 kg ha^{-1}, which is below the world average (Anonymous,2021). There is no data on hull-less barley in TUIK agricultural statistics data. Well-adapted hull-less barley cultivars have long been cultivated in many regions of the world. Although naked barley is mostly used as animal feed, its importance is increasing as human foodstuff in recent years (Balouchi et al., 2005; Mut et al., 2023). However, many researches are being carried out on the production, breeding studies, feed, food and industrial use of hull-less barley (Balouchi et al., 2005; Yalcin, et al., 2007; Blandino et al., 2015; Yuksel, 2017; Zhang et al., 2018). There are different commercial varieties and morphological forms of barley such as summer, winter, two-row, six-row, awned and awnless, hulled and hull-less, malting, used in animal and human nutrition (Ullrich, 2011). In hull-less barley (*Hordeum vulgare* L. var. *nudum* Hook f.), the palea inferior are absent or very thin. In the last two decades, barley has taken its place among nutraceutical cereals due to its higher soluble dietary fiber content compared to other cereals except oats (Derakhshani et al., 2020). Hull-less barley, which is easier to process, is mostly used as human food. Removing the hull requires extra effort and may cause nutrient loss, as well as undesirable taste and color, especially in processed products (Narwal et al., 2016).

There are very few hull-less barley cultivars registered in Turkey. New hull-less barley cultivars should be developed to provide higher yield and grain quality. The objective of this study was to determine the yield, yield components and quality traits of hulled and hull-less two-row barley (*Hordeum vulgare L.* var. *nudum* Hook f.) lines/cultivars grown in under Ispartaecological conditions in Turkey.

MATERIALS AND METHODS

The research was conducted between 2019-2020 and 2020-2021 in the experimental field of Isparta University of Applied Sciences, Faculty of Agriculture. The province of Isparta is situated in the heart of the Lakes Region, in the region where the semi-arid Mediterranean climate meets the continental climate. Isparta is located at a height of roughly 1050 meters.

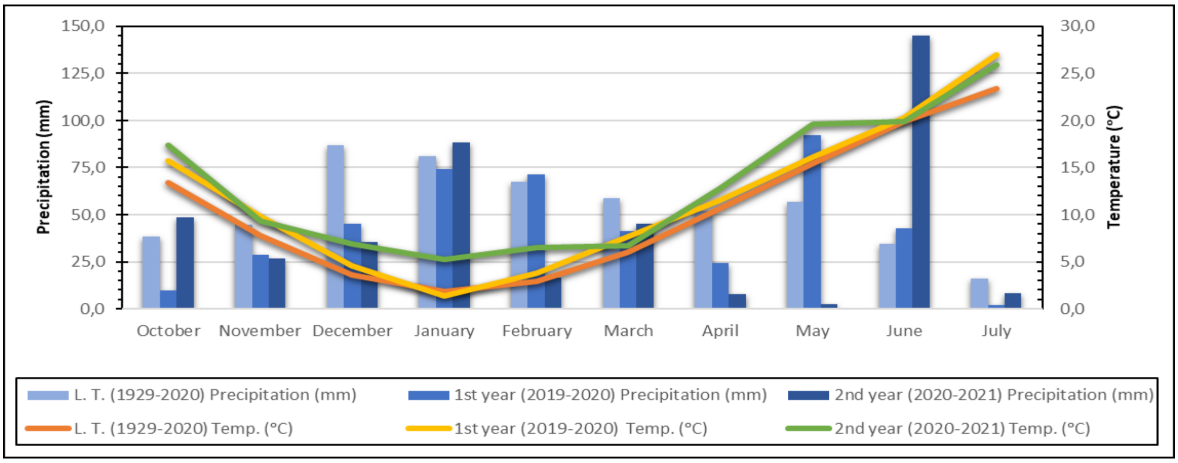

Figure 1. Temperature and precipitation data for long-term and the years in which the experiment was conducted

The average temperature of the vegetation period in the first (11.80 °C) and 2nd (13.02 °C) years was higher than the long-term average (10.66°C), while the total precipitation in the 1st (431.40 mm) and 2nd (423.9 mm) years was lower than the long-term average (536.6 mm). In the second year, it was observed that the distribution of precipitation during the vegetation period was irregular and the precipitation was very insufficient in April and May (Figure 1). Soil analysis was performed in the first year of the experiment and the soil characteristics of the experiment area were as follows: clay-loam in terms of texture, rich in lime (28.7%), poor in organic matter (1.54%), pH 7.66, poor in phosphorus (23.5 mg kg^{-1}) and rich in potassium (176.2 mg kg^{-1}).

The experiments were established according to the randomized complete block design with 3 replications (Acikgoz, 1984; Petersen, 1994). Sowing was carried out with a trial seeder at 500 seeds per square meter at 15 November 2019 and 6 November 2020. The plot area was 5.4 m^2 (5 m x 6 rows x 18 cm). Phosphorusfertilizer (60 kg ha^{-1}) and half of the nitrogen fertilizer (50 N kg ha^{-1}) were applied with sowing. The other half of the nitrogen fertilizer was applied to the plots (50 N kg ha^{-1}) in the spring at the beginning of the emergence. 2.4-D herbicide was used for weed control. In the study, the plants in the plot area that had reached full maturity were harvested. INBYT-6, INBYT-16, INBYT-18 and ABA-7 lines were harvested 8-10 days earlier than other varieties/lines. Plants were grown under dry farming conditions.

As seed material, two-row registered barley varieties Aydan Hanim (hulled), Tosun Pasa (hulled), Yalin (hull-less) and 5 hull-less barley lines (INBYT6, INBYT16, INBYT18, ABA7, ABA8) obtained from different Research Institutes (Aegean Agricultural Research Institute and Bati Akdeniz Agricultural Research Institute) were used. Some agricultural traits such as plant height, number of spikelets, number and weight of grains per spike, test and thousand grain weight, grain yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index were investigated (Akinci et al., 1999; Colkesen et al., 2002). The analysis of variance of the data obtained from the experiment was carried out using the Totemstat package program in accordance with the randomized complete block design and the averages were compared with Duncan test (Acikgoz et al., 2004).

RESULTS AND DISCUSSION

Plant height

According to the 2-year average results, plant height varied between 76.70-99.61 cm and this difference between genotypes was found significant ($P \leq 0.01$). Although plant height was higher(86.71 cm) in the second year, the difference between the years was statistically insignificant. However, since the genotypes were not similarly affected by environmental factors, the year × genotype interaction was also found significant ($P \leq 0.01$). In both years, the tallest plants were determined in Aydan Hanim variety and the shortest in INBYT6 line. According to the mean, Aydan Hanim, Tosun Pasa and Yalin varieties and other barley lines except INBYT6 line were in the same group statistically (Table 1). Plant height is affected by environmental factors (Pachepskey and Rawela, 2004) as well as genetic makeup (Whitman et al., 1985). Apical activation is also important in plant height and the development of cells depends on auxin concentration. Auxin concentration may be different among genotypes (Bak et al., 2001). This situation causes differences between genotypes in terms of plant height. In addition, the photosynthetic activity of genotypes can also be effective on plant height (Din et al., 2011). It has been reported that the average plant height values of hull-less barley genotypes ranged between 72.00-99.93 cm (Ozdemir, 2019; Tokhetova et al., 2020). In our study, although the plant height of the hull-less barley genotypes varied by year, it wasdetermined that the effect of genetic structure was more and the plant height of the hull-less barley genotypes was shorter.

Numbers of Spikelet

The average number of spikelets in barley genotypes varied between 22.54-26.86 and the highest number of spikelets was determined in Aydan Hanim and the lowest number was determined in hull-less INBYT16 line (Table 1).

Table 1. Means of plant height, numbers of spikelet and number of grains in hulled and hull-less barley genotypes

Genotypes	Plant height (cm)			Number of spikelets			Number of grains per spike		
Variety/Line	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean
Aydan Hanim	102.63 a	96.60 a	99.61 A	27.15 a	26.57	26.86 A	25.91 a	23.87 ab	24.89 A
Tosun Pasa	94.11 b	90.45 ab	92.28 A	27.16 a	26.50	26.83 A	26.80 a	23.50 ab	25.15 A
Yalin	102.24 a	88.10 bc	95.17 A	25.64 a	24.83	25.24 AB	24.44 a	23.30 ab	23.87 AB
INBYT6	65.00 d	76.70 d	70.85 C	20.89 b	25.13	23.01 B	20.04 b	22.80 b	21.42 BC
INBYT16	77.27 c	83.77 b-d	80.52 B	20.76 b	24.33	22.54 B	19.24 b	22.83 b	21.04 C
INBYT18	75.87 c	91.27 ab	83.57 B	20.86 b	24.67	22.76 B	19.27 b	23.17 b	21.22 BC
ABA7	80.50 c	85.97 bc	83.23 B	20.16 b	27.10	23.63 AB	19.01 b	25.80 a	22.41 BC
ABA8	80.98 c	80.83 cd	80.91 B	21.96 b	26.77	24.36 AB	19.96 b	25.07 ab	22.51 A-C
Mean	84.82	86.71	-	23.07 B	25.74 A	-	21.83 B	23.79 A	-
C.V.	%5.44			%7.35			%6.7		
F Value	Year (A): 1.963 ns Variety/Line (B): 23.948 ** A×B: 6.578 **			Year (A): 5.680 ** Variety/Line (B): 26.537 ** A×B: 4.081 **			Year (A): 6.880 ** Variety/Line (B): 19.655 ** A×B: 8.576 **		

**: Significant (at the alpha 5% level), **: Significant (at the alpha 1% level), ns: Not significant.*
The difference between the means shown with the same letter in the same column and row is not statistically significant.

The difference between genotypes and years was found significant (P≤0.01). The number of spikelets was higher in the second year (25.74). Since the genotypes were not similarly affected by environmental factors, the year × genotype interaction was also found significant (P≤0.01). In the first year, while the hull-less lines were statistically in the same group, the difference between the genotypes in the second year was not statistically significant. When the two-year averages were taken into consideration, all hull-less genotypes were in the same group and the number of spikelets was found to be higher in the hulled varieties (Table 1). In other studies, the average number of spikelets in hull-less barley genotypes varied between 20.73-26.43 under dry conditions and 19.86-28.40 under irrigated conditions (Yuksel, 2017). The number of spikelets in barley may vary depending on spike length, two or six rows, sparse or dense spike and variety. In different studies, a positive and significant relationship between spikelet number and grain yield was determined (Khaliq et al., 2004; Altindal, 2014).

Numbers of Grain per Spike

In the study, the number of grains per spike was higher in registered varieties. Although the number of grains of hull-less genotypes was lower than hulled varieties, Tosun Pasa, Aydan Hanim, Yalin and ABA8 genotypes were statistically in the same group (Table 1). The averagegrain number of barley genotypes varied between 21.04-25.15 and this difference between genotypes was statistically significant (P≤0.01). In the second year, the number of grains was higher (23.79) and the difference between the years was significant (P≤0.01). The year × genotype interaction in the number of spikelets was significant (P≤0.01). While there was no difference between the genotypes in terms of spikelet number in the second year, the genotypes were in statistically different groups in terms of grain number. The changes in the number of grains in genotypes are related to the number of spikelets (r=0.9112**) and spike length (r=0.8230**) (Gumus, 2022). One of the important factors affecting grain yield in barley is the number of grains and the weight of grains in the spike. Especially in cool April and May months, when there is sufficient precipitation, the number of grains and grain size increases. If this period is dry and hot, fertilization is negatively affected and the number of grains in the spike decreases (Senturk and Akgun, 2014). It was also stated that grain number was significantly affected by genotype and location (Kilercioglu, 2020).

In other studies, the number of grains per spike was 17.40-26.33 under dry conditions and 18.26-27.83 under irrigated conditions (Yuksel, 2017), 17.53-23.13 in summer sowing and 19.87-26.00 in winter sowing in 12 different barley genotypes (Ozdemir, 2019). The results of the research show that environmental factors are also effective on the number of grains per spike besides genetic structure.

Grain yield

Grain yield of barley genotypes varied between 1550.3-3675.8 kg ha^{-1} according to two-year averages. The highest grain yield was determined in the hulled Tosun Pasa variety and the lowest in the hull-less INBYT6 line (Table 2). Genotype, year and genotype × year interactions were found to be significant (P≤0.01). Grain yield decreased in all genotypes in the 2nd year. When the climatic data of Isparta conditions were analyzed, it was observed that the amount of precipitation in April and May in the 2nd year was low and the temperature values werehigh (Figure 1). This situation especially affected the fertile tillering formation. Because, although the number of spikelets and grains in the main spikes were higher in the 2nd year, grain yield decreased (Table 1). Grain yield also changed due to the effects of drought conditions on barley genotypes. In the 2nd year, when the precipitation was irregular during the vegetation period, the grain yields of the hulled varieties (Aydan Hanim and Tosun Pasa) were higher than those of the hull-less genotypes. Increasing grain yield is among the main objectives of breeding studies. In studies conducted by different researchers, it was reported that grain yield in barley can vary according to varieties, ecological factors and agricultural treatments (Akinci et al., 1999; Imamoglu and Yilmaz, 2012). In addition to factors such as the number and weight of grains per spike; plant density per unit area can also be directly effective on grain yield (Kaydan and Gecit, 2005). As a matter of fact, although high values were obtained in Aydan Hanim, Tosun Pasa and Yalin varieties in terms of number of grains per spike, grain yield was found lower in Aydan Hanim and Yalin varieties. This can be explained by the difference in the number of fertile spike per unit area of the varieties. The high biological yield in INBYT18 line in the first year also increased the grain yield. This situation shows that more spikes were formed in each m^2. When the studies on this subject were examined, that the average the average grain yield of genotypes varied according to years and growing conditions (109.12-225.05 kg da^{-1} under dry conditions, 159.37-271.63 kg da^{-1} under irrigated conditions) (Yuksel, 2017). In the study in which Yalin hull-less barley variety was used, grain yield was reported to vary between 164.56-404.39 kg da^{-1} at Bursa location and 80.03-378.41 kg da^{-1} at Balikesir conditions (Kilercioglu, 2020). In our study conducted under Isparta conditions, the average grain yield of Yalin variety was determined as 3026.5 kg ha^{-1}. This shows that environmental conditions are also effective in grain yield in addition to genetic structure. It was also reported that grain yield varies according to sowing time (Ozdemir, 2019), genotype (Kose et al., 2021) and nitrogen doses (Kilercioglu, 2020). As a result, it was determined that higher grain yield was obtained from Tosun Pasa and Aydan Hanim varieties and ABA8 line, especially in conditions where precipitation was insufficient or irregular. In irrigated conditions or when precipitation is sufficient, it can be said that INBYT18 hull-less line is also suitable for Isparta ecological conditions.

Biological yield (Stalk + Grain yield)

Biological yield is defined as the sum of seed and stalk yield. Especially in cereals where both stalk and seed are utilized, a high biological yield is a desired feature. Biological yield can also indicate the photosynthetic efficiency of the plant. According to the two-year averages, the biological yield of the genotypes varied between 8231-12840 kg ha^{-1} and the highest biological yield was determined in INBYT18 and the lowest in ABA7 lines (Table 2). Genotype, year and genotype × year interactions were found significant ($P \leq 0.01$). In the 2nd year, average biological yield (9650 kg ha^{-1}) decreased statistically significantly in all genotypes.

Tillering capacity and developmental status of barley genotypes varied from year to year due to the effects of drought conditions. In the second year of the study, biological yield was found to be higher in hulled barley genotypes than in hull-less genotypes. These results indicate that the hulled genotypes were less affected when precipitation was insufficient. In other studies, it was determined that biological yield may vary according to genotypes, years and sowing time (Tosun et al., 2000; Yildiz and Topal, 2002; Akgun et al., 2007). It was suggested that precipitation, especially during the tillering period, caused differences in biological yield (Ozseven and Bayram, 2005).

Table 2. Means of grain yield, biological yield and harvest index of hulled and hull-less barley genotypes

	Grain yield (kg ha^{-1})			Biological yield (kg ha^{-1})			Harvest index (%)		
Variety/Line	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean
Aydan Hanim	3389.6 c	3154.8 a	3272.2 B	11986.0 cd	11141.0 a	11563.0 A-C	28.38 cd	28.37 ab	28.37 AB
Tosun Pasa	4101.6 b	3250.0 a	3675.8 A	14256.0 b	11261.0 a	12759.0 AB	28.79 a-d	28.87 ab	28.83 AB
Yalin	3548.7 c	2504.4 b	3026.5 B	11418.0 d	9271.0 bc	10344.0 C	31.13 ab	27.01 b	29.07 AB
INBYT6	1564.1 e	1536.6 c	1550.3 D	5650.0 f	8707.0 cd	7179.0 D	27.73 cd	17.66 c	22.69 C
INBYT16	3604.7 c	2542.9 b	3073.8 B	13429.0 bc	9295.0 bc	11362.0 BC	26.87 d	27.40 b	27.14 B
INBYT18	4654.7 a	2750.8 b	3702.7 A	16244.0 a	9436.0 bc	12840.0 A	28.71 b-d	29.25 ab	28.98 AB
ABA7	2632.8 d	1283.5 c	1958.1 C	8772.0 e	7690.0 d	8231.0 D	30.12 a-c	16.70 c	23.41 C
ABA8	4614.1 a	3148.5 a	3881.3 A	14742.0 b	10396.0 ab	12569.0 AB	31.38 a	30.29 a	30.83 A
Mean	3513.8 A	2521.4 B	-	12062.0 A	9650.0 B	-	29.14 A	25.69 B	-
C.V.	%7.03			%7.83			%5.37		
F Value	Year (A): 95.052 ** Variety/Line (B): 262.522 ** A×B: 12.923 **			Year (A): 37.840 ** Variety/Line (B): 96.581 ** A×B: 17.948 **			Year (A): 23.006 ** Variety/Line (B): 65.740 ** A×B: 20.309 **		

**: Significant (at the alpha 5% level), **: Significant (at the alpha 1% level), ns: Not significant.*
The difference between the means shown with the same letter in the same column and row is not statistically significant.

Harvest index

According to the two-year averages, harvest index values varied between 22.69-30.83% and this difference between genotypes was statistically significant ($P \leq 0.01$). The highest harvest index was determined in ABA8 and the lowest in INBYT6 lines, but the difference between ABA8 and Tosun Pasa, Aydan Hanim, Yalin and INBYT18 lines was not significant. In the study, harvest index was significantly ($P \leq 0.01$) higher (29.14%) in the first year (Table 2). In general, genotypes with high biological yield and grain yield also had high harvest index values. Harvest index (grain yield/biological yield) is desired to be high in cool climate cereals grown for grain. Tillering and fertile spike formation capacity of genotypes may affect the harvest index and may also vary according to environmental conditions and agricultural practices. The harvest index values of Yalin variety were reported as 17.23-35.09% (Kon, 2019). Harvest index of Aydan Hanim variety varied between 35.53- 37.05% (Kaydan and Yagmur, 2007). In this study, the harvest index of Yalin variety was determined between 27.01-31.13% and Aydan Hanim variety between 28.37-28.38%. In the study in which different barley lines were used, it was determined that the average harvest index of genotypes varied according to years and growing conditions (22.33-35.24% under dry conditions, 22.79-33.54% under irrigated conditions) (Yuksel, 2017).

Test Weight

The test weight of barley genotypes showed significant difference (P≤0.01) and varied between 70.85-82.07 kg. The test weight was higher in the second year (79.82 kg) and this difference between the years was statistically significant (P≤0.01). The fact that test weight varied between years shows that environmental factors are also effective (Kendal, 2012; Yuksel and Ikincikarakaya, 2020). It was also reported that test weight varied accordingto years, growing conditions (Yuksel, 2017) and nitrogen dose applications (Kon, 2019). In the first year of the experiment, test weight was significantly higher in ABA8 and Yalin hull-less barley genotypes and in the second year, ABA8, Yalin and INBYT6 genotypes were significantly higher than the other genotypes. Although the test weight increased in all genotypes in the second year, the genotype × year interaction was significant (P≤0.01) since the rates of increase were not the same. Test weight is among the important quality criteria in barley. The shape and density of the grain in genotypes (Ozturk et al., 2001), endosperm structure and husk rate can affect the test weight (Kun et al., 1992; Sari and Imamoglu, 2009). In other studies on barley, it was reported that test weight varied between 67.74-79.31 kg (Yuksel, 2017), 65.6-79.6 kg (Kumar et al., 2021), 71.24-81.11 kg (Kose et al., 2021), 61.1-74.5 kg, 68.2-79.5 kg and 62.1-76.6 kg in different locations (Sincan, Haymana and Yenimahalle), respectively (Yalcin et al., 2007). In hull-less barley genotypes, test weight may also vary depending on sowing time (57.22-77.12 kg in summer sowing; 66.27-74.23 kg in winter sowing) (Ozdemir, 2019). As a result, in terms of test weight, ABA8 was determined as the line with higher test weight than Yalin hull-less barley variety.

Thousand Grain Weight

Thousand grain weight varied significantly depending on genotype and year (P≤0.01). The mean thousand grain weight of the genotypes varied between 29.54-45.46 g and it was determined that the thousand grain weight of the hulled barley cultivars was significantly higher than hull-less genotypes. In the second year, thousand grain weight increased in all genotypes and the average value was determined as 39.08 g in the second year. The lowest average thousand grain weight was determined in INBYT6 line in both years (Table 3). Grain size in barley is related to the amount of starch in the endosperm and affects the quality of malting or feeding. In addition to genetic structure, the number of grains in the spike, agricultural practices, ecological conditions, sowing time, climatic conditions such as temperature and drought encountered during the generative phase of the plant can be effective on thousand grain weight (Peterson et al., 1992; Kendal and Dogan, 2012; Kilercioglu, 2020). On the other hand, Sakin et al. (2004) reported that thousand grain weight is affected by genetic structure rather than environment. In a study conducted with 29 hull-less barley genotypes, thousand grain weight varied between 32.5-49.1 g and it was suggested that grain filling rate and grain filling time were important factors determining thousand grain weight (Kumar et al., 2021). It was reported that thousand grain weight was above 40 g in hulled barley genotypes, while thousand grain weight was lower and showed a wide variation (29-43.3 g) in hull-less barley genotypes (Ottekin et al., 1996). In our study results, thousand grain weight was found to be higher in hulled genotypes and lower in hull-less genotypes.

Table 3. Means of test weight, thousand grain weight and protein rate of hulled and hull-less barley genotypes

	Test weight (kg)			Thousand grain weight (g)			Protein rate (%)		
Variety/Line	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean
Aydan Hanim	70.51 b	73.50 c	72.01 DE	43.26	47.65	45.46 A	13.59 c	13.66 cd	13.63 BC
Tosun Pasa	71.60 b	76.49 c	74.05 DE	43.33	45.14	44.23 A	12.69 d	13.75 cd	13.22 C
Yalin	75.07 a	87.63 a	81.35 AB	38.71	41.49	40.10 B	12.58 d	14.96 b	13.77 BC
INBYT6	71.07 b	85.19 a	78.13 BC	28.70	30.38	29.54 F	15.75 a	16.56 a	16.16 A
INBYT16	70.21 b	80.59 b	75.40 CD	35.99	37.81	36.90 CD	14.35 b	13.25 d	13.80 BC
INBYT18	69.91 b	75.81 c	72.86 DE	35.93	40.97	38.45 BC	13.83 bc	13.71 cd	13.77 BC
ABA7	68.04 b	73.66 c	70.85 E	32.57	34.29	33.43 E	15.18 a	16.23 a	15.71 A
ABA8	78.44 a	85.69 a	82.07 A	34.04	34.95	34.50 DE	14.35 b	14.13 c	14.24 B
Mean	71.86 B	79.82 A	-	36.56 B	39.08 A	-	14.04 B	14.53 A	-
C.V.	%2.62			%4.65			%2.44		
F Value	Year (A): 27.326 ** Variety/Line (B): 192.218 ** A×B: 5.920 **			Year (A): 60.265 ** Variety/Line (B): 25.422 ** A×B: 0.716 ns			Year (A): 55.359 ** Variety/Line (B): 23.786 ** A×B: 13.896 **		

**: Significant (at the alpha 5% level), **: Significant (at the alpha 1% level), ns: Not significant.*
The difference between the means shown with the same letter in the same column and row is not statistically significant.

Protein Rate

Protein rates varied between 13.22-16.16% and these differences between genotypes were found to be statistically significant ($P \leq 0.01$). It was determined that the protein rate was higher in the 2nd year (14.53%) and this difference between the years was statistically significant ($P \leq 0.01$). In both years of the experiment, the highest protein content was determined in INBYT6 and ABA7 hull-less barley genotypes, while the lowest was determined in Yalin (12.58%) in the first year and INBYT16 (13.25%) genotypes in the second year. In general, except for INBYT16 and ABA8 genotypes, protein rate was higher in the second year in other genotypes. This difference between the years in protein rate caused the genotype × year interactions to be significant ($P \leq 0.01$) (Table 3). Since hull-less barley can be easily separated into bran and flour by conventional wheat milling equipment, there is no loss of nutrients (Karaduman, 2006). Therefore, for the direct consumption of barley as food, hull-less varieties are preferred and high protein content is desired. Protein rate in barley is affected by environmental factors as well as genetic structure. Especially precipitation during the grain filling period can affect the protein rate (Hurkman et al., 2009; Biruk and Demelash, 2016).

When other studies on this subject were examined, it was reported that the average protein ratein hull-less barley genotypes varied between 14.0-16.2% by Tokhetova et al. (2020), 13.95-18.09% by Kose et al. (2021) and 9.2-14.3% by Kumar et al. (2021). It was also revealed by different researchers that protein rate varies according to years and agricultural practice (Kon, 2019; Yuksel and Ikincikarakaya, 2020). In our study, protein rate of Yalin hull-less barley variety varied between 12.58-14.96%. In the study Yalin was used, the average protein rate varied between 10.36-14.66% year according to nitrogen doses (Kon, 2019). As a result, it was determined that the protein rate was higher in hull-less barley genotypes. In addition, since there is a positive correlation between beta glucan rate and protein rate (Kumar et al., 2021), it can be said that lines with high protein rate will also have higher beta glucan rate.

CONCLUSION

In this study, 8 different barley genotypes (Aydan Hanim, Tosun Pasa, Yalin, INBYT6, INBYT16, INBYT18, ABA7 and ABA8) were compared in terms of grain yield and quality traits and especially the adaptability of the hull-less barley lines to Isparta ecological conditions were determined. The vegan/vegetarian diet, which has become popular in recent years, directs people to alternative fiber sources and plant products with high protein content. Barley is recommended as a healthy food in human nutrition because it has the lowest glycemic index and high beta glucan (especially β-1-3;1-4) content among cereals. According to the two-year results, it was determined that hull-less barley genotypes can grow in Isparta ecological conditions and the highest grain yield was obtained from INBYT-18 and ABA8 lines. In addition, INBYT6 and ABA7 lines can be recommended to be used as parents in crosses to increase the protein rate.

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